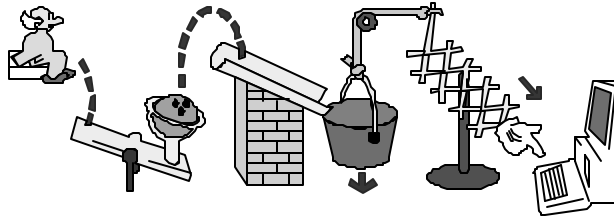# Software Change Impact Analysis
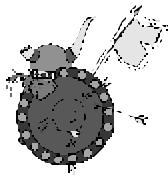
September, 2000
Leanna Rierson
National Resource Specialist
for Aircraft Computer Software

**Leanna.Rierson@faa.gov**

History (1/2)

- Major/Minor change classification issues have existed for years.
- 1993-1996 - Certification Authorities Software Team (CAST) developed a position paper on major/minor software classification.
- 1998 - Streamlining Software Aspects of Certification (SSAC) Industry Workshop participants raised issue regarding FAA policy on major/minor software changes.

History (2/2)

- 1998-1999 - FAA and industry worked together to develop a position addressing major/minor classification of software changes.
- Result: Software change impact analysis guidelines.
- Policy: Notice entitled **"Guidelines for the Oversight of Software Change Impact Analysis Used to Classify Software Changes As Major or Minor."**
- Status: Notice Signed on May 12, 2000

Notice N8110.85 Outline

- Title: "Guidelines for the Oversight of Software Change Impact Analysis Used to Classify Software Changes As Major or Minor"
- Section 1: Purpose
- Section 2: Distribution
- Section 3: Related Publications
- Section 4: Background
- Section 5: Discussion
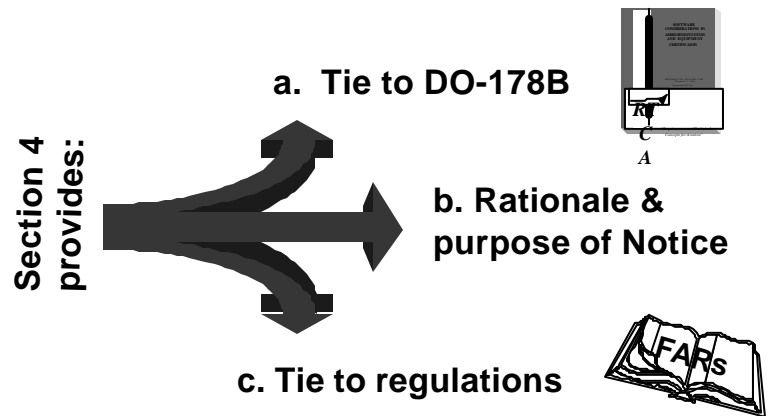- Section 6: Procedures
- Section 7: Conclusion
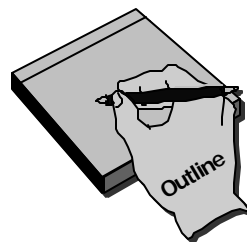
Section 1-3: Purpose, Distribution, Related Publications

- Section 1 - Purpose
  - To provide a standardized process for assessing the safety impact of software changes & determining FAA's involvement in software changes
- Section 2 - Distribution
  - FAA and designees
- Section 3 - Related Publications
  - Advisory Circular 20-115B
  - RTCA/DO-178B
  - Part 21

Section 4 - Background

Overview of Section 4

Section 4 provides:

a. Tie to DO-178B

b. Rationale & purpose of Notice

c. Tie to regulations

Tie to DO-178B

- AC 20-115B recognizes DO-178B as a means of compliance to the FARs

- DO-178B addresses software changes in Section 12.1

Tie to Regulations

- Regulations address major/minor changes in:
  - 21.93(a) and 21.95 - Type Certification
  - 21.611(a), (b) - Technical Standard Order (TSO)
- Regulations look at changes from the product perspective

FAR Quotes (1/2)

- 21.93(a) states that a "'minor change' is one that has no appreciable effect on the weight, balance, structural strength, reliability, operational characteristics, or other characteristics affecting the airworthiness of the product. All other changes are 'major changes' …".

- 21.95 states: "Minor changes in a type design may be approved under a method acceptable to the Administrator before submitting to the Administrator any substantiating or descriptive data."

FAR Quotes (2/2)

- 21.611 (a) and (b) addresses "minor" and "major" changes for TSO manufacturers. 21.611(a) basically says that minor changes (i.e., a change that's not major) may be made without further approval by the FAA. The revised data should be submitted to the appropriate ACO. 21.611 (b) states that "Any design change by the manufacturer that is extensive enough to require a substantially complete investigation to determine compliance with a TSO is a major change."
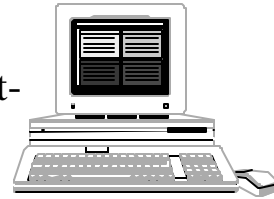
Types of Software Changes (1/2)

- Pre-Certification
  - During software development/before software approval
  - Change control in place
  - Problem reporting & correction in place
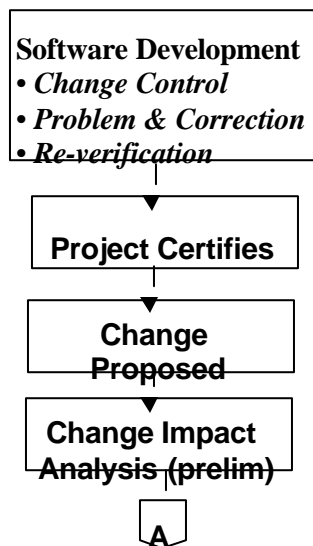 - Re-verification in place
  - Addressed in Sections 7 & 8 of DO-178B
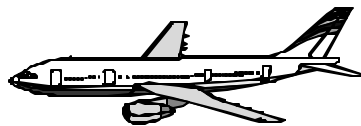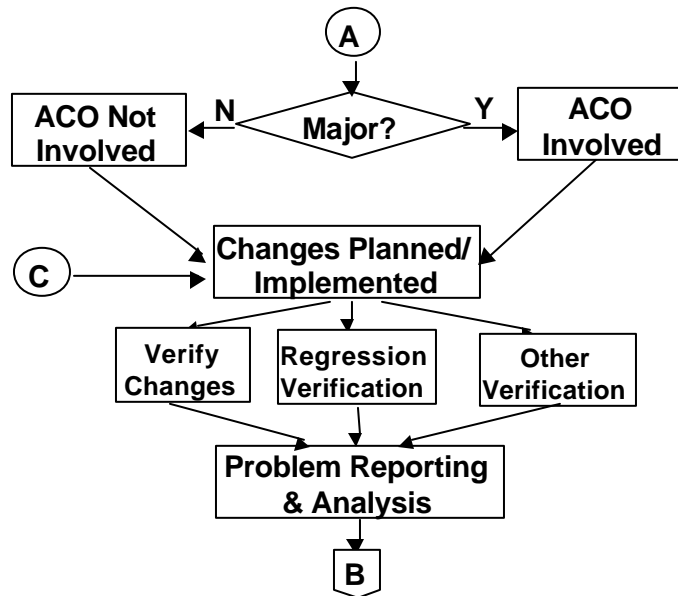
Types of Software Changes (2/2)

- Post-Certification
  - After software approval and product certification
  - Section 12.1 of DO-178B ("Use of Previously Developed Software") addresses this kind of change
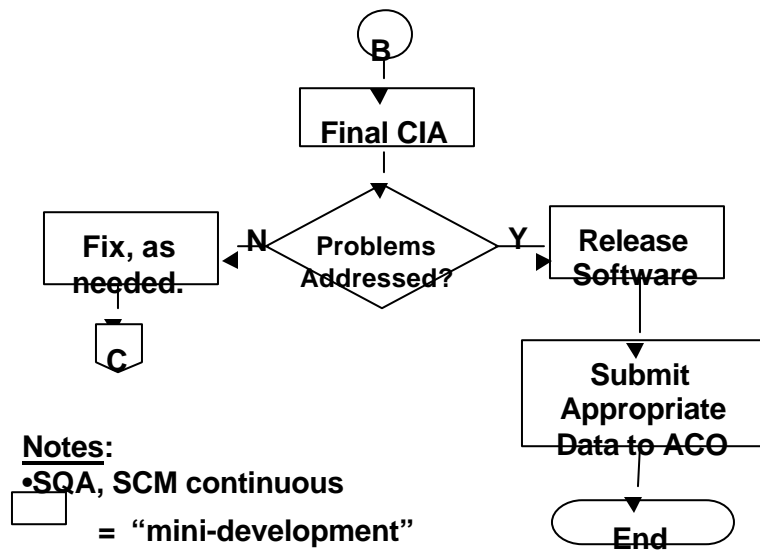 - N 8110.85 focuses on the post-certification change

Big Picture Look at Software Changes (1/3)

Software Development
- *Change Control*
- *Problem & Correction*
- *Re-verification*

↓

Project Certifies

↓

Change Proposed

↓

Change Impact Analysis (prelim)

↓

A

Big Picture Look at Software Changes (2/3)

A

Major?

N → **ACO Not Involved**

Y → **ACO Involved**

C →

Changes Planned/ Implemented

Verify Changes

Regression Verification

Other Verification

Problem Reporting & Analysis

B

Big Picture Look at Software Changes (3/3)

B

Final CIA

Problems Addressed?

N → **Fix, as needed.**

C

Y → **Release Software**

Submit Appropriate Data to ACO

End

Notes:
•**SQA, SCM continuous**

= "mini-development"

## Purpose of Change Impact Analysis (1/2)

- Assess affects of the software change on system performance, safety, documentation, …
- Assess the classification of the change (E.g., major, minor, significant, insignificant)
- Determine amount of rework and verification required
- Plan for the change (resources, cost, schedule, …)

Purpose of Change Impact Analysis (2/2)

- Identify what is affected by the change
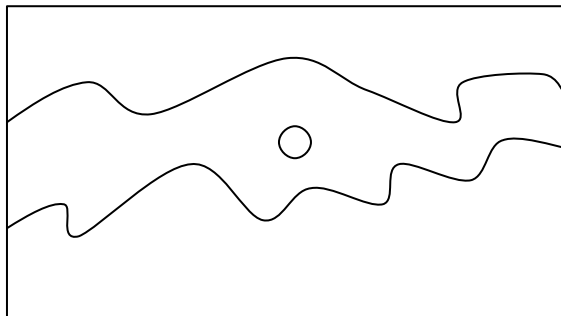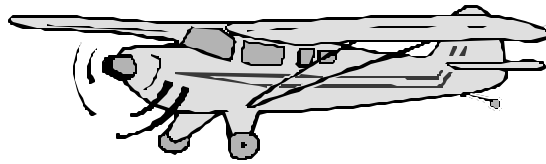
Section 5 - Discussion

Overview of Section 5

- Technical "meat" of the Notice
  - "WHAT", not "HOW"
- 3 Sub-Sections:
  - 5a) Items to be addressed by CIA, as applicable
  - 5b) Examples of changes that could cause adverse affects
  - 5c) Updating data & verification

Section 5a: Potential Items to Be Addressed in CIA

- Traceability Analysis
- Memory Margin Analysis
- Timing Margin Analysis
- Data Flow Analysis
- Control Flow Analysis
- Input/Output Analysis
- Development Environment & Process Analyses
- Operational Characteristics Analysis
- Certification Maintenance Requirements (CMR) Analysis
- Partitioning Analysis

Traceability Analysis

- VERY IMPORTANT!
- Identifies areas affected by the software change:
  - Requirements & Design Analysis
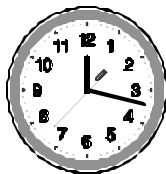 - Code Analysis
  - Test Procedures and Cases Analysis
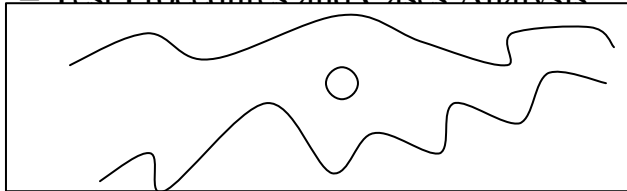
Memory Margin Analysis

- Assure memory allocation requirements and margins are maintained.
- Examples of tasks:
  - Estimate change to flash memory
  - Estimate change to RAM
  - Evaluate memory margins
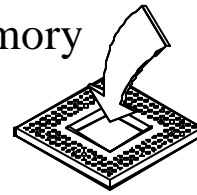
Timing Margin Analysis

- Assure timing margin issues are not introduced due to the change.
- Examples of tasks:
  - Review timing requirements
  - Review CPU task scheduling requirements
  - Review interface timing requirements
  - Review changes to the timing margins (usually want at least 10% margin)
 - Review throughput change for each task

Data & Control Flow Analysis

- DO-178B, Table A-7, Objective 8 requires data & control coupling for Levels A, B, and C software.
- Data & control flow analysis assesses changes in data & control flow and coupling between software components.
    - Examples of software components are procedures and functions.
- Data & control flow analysis also evaluates any adverse affects due to the change.

Input/Output Analysis

- I/O Analysis evaluates impact of the change on the interface with the external world:
- Examples of tasks:
    - Bus loading
    - External databus I/O
    - External hardwire I/O
    - Access to memory
    - Communication with hardware

Development Environment & Process Analysis

- Identifies changes in the environment or process that might have adverse affects on the system:
- Examples include changes to:
  - Compilers
  - Linkers
  - Loaders
  - Tools
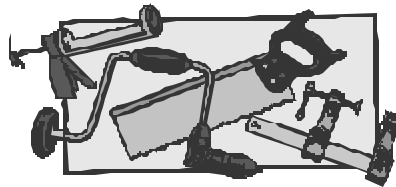
Operational Characteristics Analysis

- Identifies adverse effects in the operational environment due to software changes.
- Examples of changes that could affect the operation of the product:
  - Gain changes
  - Limit changes
  - Filter changes
  - Interrupt changes
  - Exception handling changes
 - Fault mitigation changes

Certification Maintenance Requirements (CMR) Analysis

- Determines if the software change requires new or modified CMR.
- Example:
  - Assume the software change to the anti-skid systems increases the time that the brakes are applied during landing. This could result in more frequent maintenance of the brakes and tires.

Partitioning Analysis

- Determining the affect of the software change on the protective mechanisms.

  - Data Coupling
  - Hardware Resources
  - **Other Failure Modes**
 - **Control Coupling**
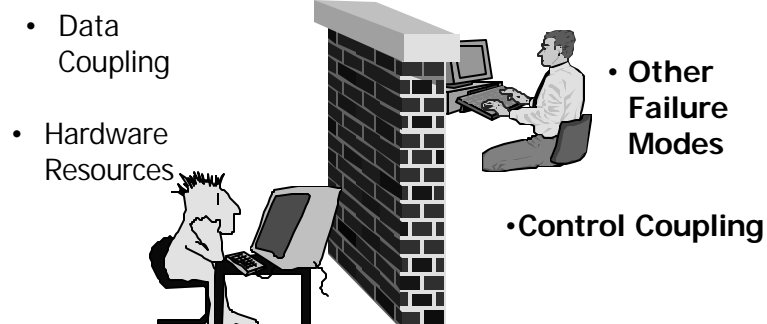
Section 5b. Examples of Adverse Affects (1/2)

- When performing the CIA activities, the <u>focus is going to be on adverse affects</u>. I.e., things that affect operation and safety.
- Section 5b provides examples of typical categories of change impact:
  - Change in safety-related information
  - Change in operational or procedural characteristics of the aircraft
  - New functions
  - Different interfaces
  - Significant change to life cycle data

Section 5b. Examples of Adverse Affects (2/2)

- Changes that have adverse impacts will likely lead to a "major" change classification.
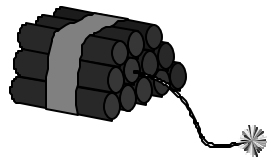
5c. Updates and Verification

- Applicant updates necessary software life cycle data, whether the change is major or minor.
- Applicant verifies the software change to make sure there are no adverse effects. Example verification activities:
  - Reviews
  - Analyses
  - Regressions testing
  - Requirement-based testing
  - Flight testing

Changes to Requirements (most common change)

- new
- modified
- deleted

Developer's Role For New/Changed Requirement (1/4)

- Perform CIA to assure that the new or changed requirement:
  - does not conflict with other requirements
  - is unambiguously stated and verifiable
  - is verified to meet requirements of software level
  - achieves desired functionality

Developer's Role For New/Changed Requirement (2/4)

- Assure that the following are completed, as needed:
  - update the software architecture
  - change prologue headers
  - review changes against standards
  - update traceability (both forward and backward)

Developer's Role For
New/Changed Requirement (3/4)

- Examine data elements to assure that new or changed code does not negatively impact existing functionality by:
    - examining all areas of the code that use the same variables as those in the changed or new code
    - re-examining variable declarations and interfaces
    - examining control flow to assure that the change does not negatively impact execution sequence or timing

Developer's Role For
New/Changed Requirement (4/4)

- Assure that:
    - Verification test cases for new and changed requirements exist
    - All requirements-based tests (normal and robust) that trace to new or changed requirements are run or re-run
    - Structural coverage is achieved for new or changed area, and still achieved for areas of code with dependencies
    - Verification record that documents the regression analysis exists

FAA's Roles For New/Changed Requirement

- Review CIA, as needed
- Oversee the applicant's activities, when the change is "major"
- Oversee designees
- Perform on-site or desk-top reviews, as needed

Examples of Change Impact Analyses (1/2)
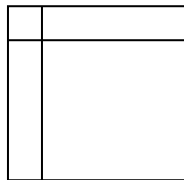
Tables/Forms

Automated Tools

Change
Impact
Analysis

Fly-Today Company

Ground-Proximity Warning System
FTC-2100
Revision A
3/24/00

Formal Reports

Examples of Change Impact Analyses (2/2)

- CIAs come in many forms
  - Some Formal
  - Some Informal
- No single correct format
- Extent of analysis depends on the change size and affected items
- Important to have the information available to make the necessary decisions

Example of a Tool Used in CIA

Code Files Effected

Rqmts Effected

Change Request (CR)

Design Parts (code, req, or both)

Test Change Request (TCR) (shows test effected)

Work Packet (WP) (used to group CRs into deliveries to customer)

Overview of Section 6

```
                    ┌──────────┐
                    │  Start   │
                    └────┬─────┘
                         │
  ┌─────────────┐   Y  ◇ Classification ◇  N   ┌─────────────┐
  │ 6a - Follow │◄──────  Procedure  ──────────►│ 6b - Work   │
  │ Procedure   │        in Place?              │ w/ ACO to   │
  └──────┬──────┘                               │ Classify    │
         │                                      └──────┬──────┘
         │                                             │
         │          ◇  Change  ◇                       │
      N  └─────────── Major? ───────── Y ───────────────┘
         │                                             │
  ┌──────┴──────┐                               ┌──────┴──────┐
  │ 6c - ACO not│                               │ 6d - ACO    │
  │ involved    │                               │ involved    │
  └─────────────┘                               └─────────────┘
```
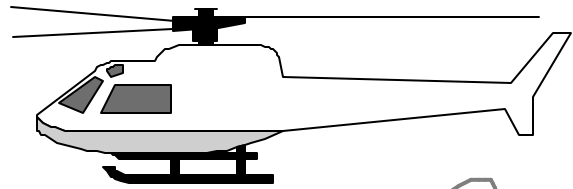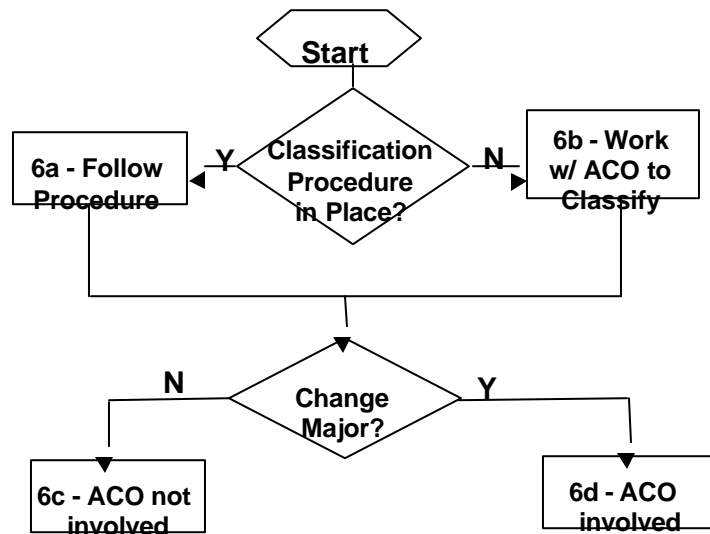
6a - Applicant Has Classification Procedures (1/2)

- Procedures in place to classify changes as major or minor
- Reference FAR Part 21
- Procedures should be reviewed & approved by the ACO
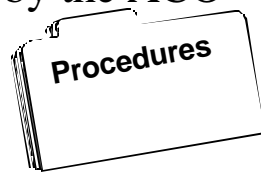
Procedures

6a - Applicant Has Classification Procedures (2/2)

- Procedures should contain a process for:
  - Using CIA to classify change
  - Reviewing/approving the classification
  - Addressing minor changes
  - Addressing major changes
  - Informing FAA (e.g., PSAC, SAS, report, …)
  - Obtaining FAA concurrence on changes

6b - Without Classification Procedures

- FAA more involved
- Applicant performs CIA (using Notice)
- Applicant proposes classification (major or minor) to FAA
- FAA reviews/accepts/modifies the classification
- Applicant & FAA follow 6c for minor and 6d for major changes
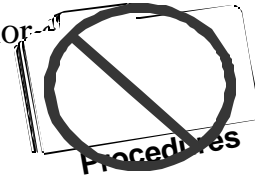
6c - Minor Changes

- Change performed without FAA involvement
- Data updated, as required
- Software Accomplishment Summary (SAS), Software Configuration Index (SCI), and/or other documents submitted to FAA on a periodic basis
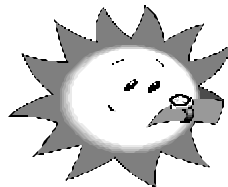
6d - Major Changes

Major

- FAA and/or DER involved
- PSAC and/or CIA submitted to FAA as agreed upon
- SAS, SCI, and/or other agreed upon data submitted to ACO
- ACO and/or DER reviews and approves data, as needed

Section 7 - Conclusion

- Notice is only a supplement AC 20-115B and DO-178B
- Guidelines only
- Variance from national policy should be coordinated with AIR-130

Video Availability

- May 12, 2000 - Interactive Video Teletraining Delivered to FAA
- Videos Available for Designees and Industry
- Self-Study Guide & Order Form Available on Web-site:
  - http://av-info.faa.gov/software
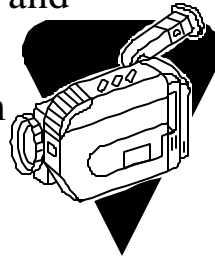
Paper On Software Changes

- Paper Title: "**A SYSTEMATIC PROCESS FOR CHANGING SAFETY-CRITICAL SOFTWARE**"
- **Being presented at Digital Avionics Systems Conference in October**
- **Addresses typical things to consider when making changes to software**
- Available on Web-site:
  - http://av-info.faa.gov/software

Summary

- •Purpose of Notice is to provide guidelines for addressing changes to software.

- •Intended to allow flexibility but encourage more standardization.

- •Notice encourages use of CIA to serve as input into the major/minor classification.

- •Send comments, questions, etc. to myself and/or Dennis.Wallace@faa.gov.

General Questions/Answers